The Management of Chondromalacia Patellae: A Long Term Solution

Patellofemoral pain syndrome can be a difficult condition to manage effectively. The success rate of most treatment regimes has been poor and in the long term the condition frequently recurs.

The author has developed a treatment programme which has a ninety-six per cent success rate. Long term follow up of patients, after twelve months demonstrated that all patients reviewed have remained pain free.

The programme involves two major components: a thorough understanding of the mechanics of the patellofemoral joint so that an adequate assessment of the patient's lower limb can be made, and context specific training of certain muscles which contribute to patellar alignment. This training must be relatively pain free so that muscle control can be enhanced.

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Patellofemoral pain is a common, yet poorly managed condition presenting to physiotherapists and other practitioners. The incidence in the general population is reported to be as high as one in four with this proportion increasing in the athletic population (Levine 1979, Outerbridge 1964). The condition, which generally has an insidious onset, is characterized by a diffuse ache in the vicinity of the patella (Levine 1979, Malek and Magine 1981, Outerbridge 1964). It is often given the diagnosis of chondromalacia patellae, but this diagnosis is only appropriate if softening and fissuring of the undersurface of the patella has been visualized either directly during surgery or arthroscopy or indirectly by means of an arthrogram (Devereaux and Lachmann 1984, Ficat and Hungerford 1977). In fact, many patients with severe pain and functional disability do not have any pathological findings (Andrish 1985). Their pain, which is often exacerbated by sporting activities, stair climbing and prolonged sitting with flexed knees ('movie goers knee') can be extremely difficult to treat (Levine 1979, Micheli and Stanitski 1981). Thus results of management, whether it be conservative or surgical, are equivocal and much confusion abounds for the practitioner as to the most expedient method/methods of diminishing the patient's symptoms so that sporting and other recreational pursuits can be resumed as quickly as possible.

Initially, patients are managed conservatively. This often involves a combination of the following measures — quadriceps strengthening exercises (this includes quadriceps setting, straight leg raises, isotonic exercises in the last 30° of extension), ice or heat, ultrasound, patellar mobilizations, nonsteroidal anti-inflammatory drugs, faradic stimulation of vastus medialis, isokinetic exercise for quadriceps and hamstrings, hamstring stretches, cast immobilization, shoe orthotics and/or walking aids (Gruber 1979, Insall 1979, LeVeau and Rogers 1980, Levine 1979, Malek and Magine 1981, Micheli and Stanitski 1981, Outerbridge 1964, Smillie 1978, Soderberg and Cook 1983, Wild and Franklin 1982). It seems, however, that the decrease in symptoms made during the treatment period is, in many cases, only temporary, because several investigators have found at a twelve month follow up that only 30% of patients have remained symtom free (Devereaux and Lachmann 1984).

If conservative management fails, then surgery is the next option, but surgical management is fraught with difficulties because of the complex nature of the extensor mechanism and the problems resulting from compromised knee function. Fortunately, more radical surgery such as patellectomy, a relatively common procedure five years ago and having extremely detrimental effects on knee joint mechanics, is rarely performed today (O'Donoghue 1981). Recent evidence has cast doubt on the efficacy of more conservative operative procedures such as medial alignment of the tibial tubercle to decrease the Q angle (see the definition below). Huberti and Hayes (1984), working on cadaveric knees, found that both increased and decreased Q angles were associated with peak patellofemoral pressures and unpredictable patterns of cartilage unloading at different locations on the patella. They concluded that a decreased as well as an increased Q angle could be a potential aetiological factor in chondromalacia. This may help to explain why some patients who are initially symptom free following surgery have a return of symptoms later.

The overall poor results achieved in managing patellofemoral pain and the successful identification of certain biomechanical factors which predispose an adolescent to patellofemoral pain (McConnell 1984), prompted the author to implement a quite different management programme.

Mechanics of the Patellofemoral Joint

For effective management of patellofemoral pain an understanding of the mechanics of the patellofemoral joint is required. The function of the patella is to link the divergent quadriceps muscle to a common tendon, so increasing the quadriceps lever arm and thus its mechanical advantage (Ficat and Hungerford 1977). For efficient functioning of this mechanism the patella must be aligned so it remains in the trochlear notch of the femur. Malalignment of the patella from altered mechanics will predispose an individual to patellofemoral pain and possibly articular cartilage breakdown (Goodfellow *et al* 1976, Insall 1979). The individual with patellofemoral pain will then experience increased pain when the knee is flexed because the patellofemoral joint reaction force (PFJRF) increases with flexion of the knee from 0.5 times body weight during level walking to three to four times body weight when ascending or descending stairs and seven to eight times body weight during squatting (Ficat and Hungerford 1977, Reilly and Martens 1972).

Factors Affecting Patellar Alignment

Many parameters have been cited in the literature as causing malalignment of the patella and hence pain. These are increased Q angle, muscle tightness, excessive pronation, patella alta and vastus medialis insufficiency.

Q Angle

This is regarded by many investigators as the single most important factor contributing to patellofemoral knee pain. The Q angle is the angle formed by the intersection of the line of pull of the quadriceps and the patellar tendon measured through the centre of the patella. The outer limit for normal Q angle is 13-15°. An increase in Q angle which may be associated with increased femoral anteversion, external tibial torsion and lateral displacement of the tibial tubercle increases the lateral pull of the patella (Ficat and Hungerford 1977, Gruber 1979, Insall 1979, Malek and Magine 1981).

Muscle Tightness

There are structures which, when tight, are reported to have an effect on patellar alignment. These are:

- rectus femoris which, if tight, affects patellar movement during knee flexion.
- iliotibial band which, if tight, will pull the patella laterally during knee flexion (McNicol 1981, Nobel 1980).
- hamstrings which, if tight, will during running cause increased flexion of the knee thus increasing the PFJRF in stance (Winter 1983). It has been suggested that the increased knee flexion will cause an increase in ankle dorsiflexion which cannot be adequately fulfilled by the talocrural joint so that the subtalar joint assists, resulting in compensatory pronation (Root *et al* 1977).
- gastrocnemius which, if tight, will also result in a compensatory pronation because dorsiflexion at the talocrural joint cannot occur and the movement is translated to the subtalar joint (Root *et al* 1977).

Excessive Pronation

Prolonged pronation of the subtalar joint is accompanied by a prolonged internal rotation of the leg resulting in malalignment of the patella and internal rotation of the femur. The quadriceps, therefore will pull the patella laterally (Buchbinder *et al* 1979, Subotnik 1980). In adolescent boys, subtalar pronation, not Q angle, was found to be the single most significant predicator of patellofemoral pain (.003 level of significance) (McConnell 1984).

Patella Alta

This is measured by means of a lateral roentgenogram where the height of the patella and the distance from the inferior pole of the patella to the tibial tubercle (*ie* the patellar tendon length) are determined. Patella alta is present when the measurement of the length of the patella tendon is twenty per cent greater than the measurement of the height of the patella. The consequent high sitting of the patella predisposes the individual to patellar subluxation (Insall 1979).

Vastus Medialis Obliquus (VMO) Insufficiency

The function of vastus medialis obliquus is to realign the patella during extension of the knee (Basmajian 1970, Lieb and Perry 1968). It is the only dynamic medial stabilizer; any insufficiency of this muscle will increase the lateral drift of the patella (Gruber 1979, LeVeau and Rogers 1980).

As there is increasing debate over the relative merit of physiotherapeutic management which includes straight leg raise with and without weights (Bohannon 1983, Kramer and Sample 1983, LeVeau and Rogers 1980, Micheli and Stanitski 1981, Pevsner *et al* 1979, Soderberg and Cook 1983, Smillie 1978, Wild and Franklin 1982) and the relative ability of exercise to specifically influence vastus medialis activity (LeVeau and Rogers 1980, Reilly and Martens 1972, Reynolds *et al* 1983) the author undertook a clinical trial which emphasized specific training of certain muscles of the lower extremity. It was thought that if a patient's symptoms were a result of poor mechanical alignment, then alteration of this alignment should decrease the symptoms. To overcome the lateral tracking of the patella in the symptomatic individual, any tight lateral structures would have to be elongated and the vastus medialis obliquus would have to be functioning as well as, if not better than, that of an asymptomatic individual. It has been found that there is no significant difference in activity of vastus medialis and vastus lateralis in asymptomatic individuals (Reynolds *et al* 1983) but a decrease in VMO activity compared with vastus lateralis (VL) activity exists in patients with patellar subluxation (Mariani and Caruso 1979).

As vastus medialis is active throughout the full range of extension and the entire quadriceps muscle needs to generate 60% more tension in the last 15° of extension to complete the movement (Lieb and Perry 1968), how is it possible to more selectively train vastus medialis? There are five aspects which need to be considered before deciding how a patient should perform quadriceps exercises.

1. *The position of the femur*

When the femur is internally rotated, knee extension is assisted by the tensor fascia lata muscle through its attachment into the iliotibial band (Kaplan 1958). This increases the lateral pull on the patella and thus decreases the effectiveness of the vastus medialis obliquus (McNichol 1981).

2. *The origin of the VMO fibres*

Bose (1980) found after dissecting the quadriceps muscle, that the maximum amount of VMO fibres originate from the tendon of the adductor magnus, therefore the addition of adduction while performing knee extension might facilitate VMO activity during early stages of rehabilitation (Bose *et al* 1980).

3. *The effect of pain on muscle contraction*

Pain has an inhibitory effect on quadriceps muscle contraction particularly if it is accompanied by knee joint effusion (de Andrade *et al* 1965, Spencer *et al* 1984, Stratford 1981). Consequently, extreme care should be taken not to exacerbate the pain with exercises because this exacerbation will only be detrimental to the patient's rehabilitation and rather than enhancing muscle activity with exercise, muscle inhibition and subsequent atrophy will occur (Stratford 1981). However, it has been found that isometric quadriceps contractions are inhibited less with the knee in a flexed position (Stokes and Young 1984).

4. *Specificity of training*

Training of a muscle should be specifically tailored for the demands placed on that muscle (Sale and MacDougall 1981) Training effects are specific to limb position, joint angle, limb velocity and type of contraction (Moffroid and Whipple 1970, Sale and MacDougall 1981, Winter 1983).

5. *Feedforward adjustments*

Adjustment occurs in a muscle so that it is 'set' in advance for a particular activity. The feedback mechanism is too slow to fine tune for any error because by the time the information is received the muscle is already in a new position (Krebs *et al* 1983, Tuller *et al* 1982). However, it may be possible to train a muscle to respond to a new length/tension ratio, that is, to retune this feedforward mechanism.

So, consider an individual who experiences patellofemoral pain when ascending and descending stairs or squatting while gardening or jogging down hills. Given the above factors, how effective would a regime of straight leg raises with or without weights, or isokinetic exercises be in achieving a rapid symptom free status for this individual?

Clinical Trial

Thirty-five patients from the ages of 12 to 37 years are currently participating in the study, twenty females and fifteen males (see Table 1). Twenty-three have been referred by a medical practitioner, nine were word of mouth referrals and three from other sources (Table 2).

The mean duration of symptoms was 4.9 years with a range from one month to a nineteen year history of symptoms (Table 3). Eighteen of the patients had bilateral symptoms, the rest had unilateral symptoms. A summary of area and region of pain is in Tables 4 and 5.

Table 1:
Age range and sex of trial subjects

Ages	Male	%	Female	%
12-16	3	8.5	5	14
18-22	4	11.5	9	26
24-28	6	17	4	11.5
30-34	2	5.7	1	3
36-38	0	0	1	3

Table 2:
Method of referral

Referrals	Number	%
Sports Medicine	15	43
General Practitioner	5	14
Rheumatologists	3	8.5
Word of Mouth	9	26
Other	3	8.5

Table 3:
Duration of symptoms

Months/Years	Number of patients	%
1-3 months	4	11.5
3-6 months	6	17
6-12 months	9	26
1-2 years	8	23
2-5 years	2	5.7
>5 years	6	17

Table 4:
Distribution of pain sites

Site of Pain		*Number of Patients*	*%*
Unilateral	R	9	26
	L	8	23
Bilateral	R = L	2	5.7
	R > L	6	17
	L > R	10	28.5

Table 5:
Distribution of pain areas

Area of Pain	*Number of Patients*	*%*
Lateral	10	28.5
Medial	5	14
Retro/Peri	12	34
Inferior	3	8.5
Superior	0	0
Nonspecific	5	14

Table 6:
Summary of activities producing symptoms

Subjective	*No of Pat.*	*%*	*Objective*	*No. of Pat.*	*%*
Stairs	17	48.5	Stairs	11	31
Squat	5	14	Squat	18	51
Movie-goers Knee	20	57	Other	6	17
Other	6	17			

Twenty-seven of the thirty-five patients had received previous treatment with little success, the majority having received physiotherapy treatment *ie* straight leg raise with weights, and isokinetics; four had undergone surgery.

The following information was obtained from the patients' histories. Twenty complained of 'movie goers knee', seventeen were subjectively symptomatic on stairs, five felt they had to go into a squat position before they were symptomatic and six reported that they required more stressful loading such as tumbling in gymnastics or jumping in netball before their pain was reproduced. Objectively, pain was reproduced in eighteen patients by squatting, in eleven by ascending and descending stairs, and in six by other means such as one leg squat, duck walk or jumping (Table 6).

There were some marked similarities in the presenting biomechanical characteristics of the subjects and an individual subject could exhibit more than one of these characteristics. A summary of findings is presented in Table 7. The most common findings were pronated feet, tight iliotibial band and squinting patellae which were seen in 22, 21 and 15 subjects respectively. Tight hamstrings and increased Q angle were found in only ten subjects. A number of subjects had weakness of one of their hip rotators. There were only three subjects who did not have pain on the critical test, developed by the author. Their pain was reproduced on more strenuous testing.

The critical test is a test performed with the patient in high sitting and involves isometric quadriceps contractions at five different flexion angles, namely 120, 90, 60, 30 and 0°, while the femur is externally rotated. The contraction is sustained for at least ten seconds because often the pain is delayed in onset. It has been found in preliminary investigations that the VMO has phasic rather than tonic activity in patellofemoral pain sufferers whereas VMO activity is tonic in subjects with no patellofemoral pain (Richardson 1985).

If pain is reproduced during any of the isometric contractions the patient's leg is brought back up to full extension. In this position the patella is no longer in contact with the femur, hence it can be moved relatively easily. The patient's lower leg is supported on the therapist's knee so that the patient can fully relax the quadriceps muscle, thus enabling the therapist to glide the patella medially. The glide is performed using both thumbs flattened against the lateral border of the patella (Figure 1).

This glide is maintained while the patient again performs the isometric contraction at the position which was previously painful. This time there should be a significant reduction in pain, if the pain is patellofemoral in origin. The therapist can then be quite confident in predicting a favourable outcome for the patient, provided of course that the patient is prepared to be involved in the training programme. Most patients are more than happy to be involved because they are so delighted to be free of pain.

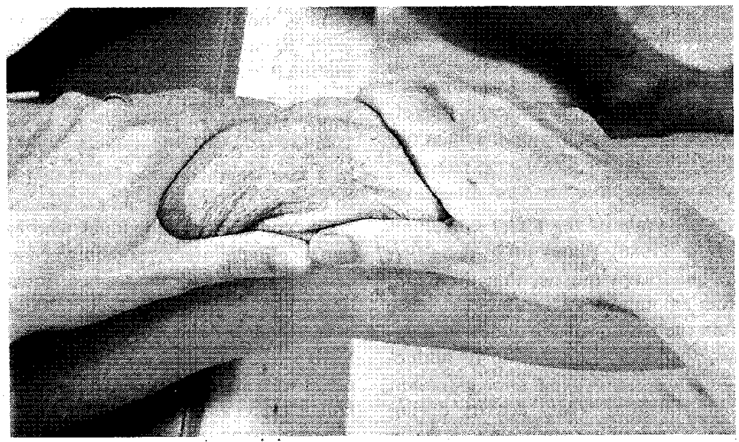

Figure 1: Medial glide of the patella.

Table 7:
Biomechanical characteristics

	Both Legs Affected Equally	Unilateral Problem: Greater in Asymptomatic knee	Unilateral Problem: Greater in Symptomatic knee	Bilateral Problem: Greater in Less Symptomatic knee	Bilateral Problem: Greater in More Symptomatic knee	Total %
Pronation increased	8	1	1	2	10	62.8
Q angle increased			4	4	8	28.5
Decreased iliotibial band	9		3	1	2	60
Squinting Patellae	7		1	2	5	42.8
Hyperextension	3		2	1	1	20
Hamstring length decreased	8				2	28.5
Leg length				1	1	5.7
Other	1		4		17	62.8

Isometric Quadriceps

Angle	*Number*	*%*
All	4	11.5
0 + 60	9	26
60 + 90	0	0
0 + 90	1	3
0	7	20
30	6	17
60	1	3
90	4	11.5
120	1	3
no pain	3	8.5

Passive Movements

	Number	*%*
Patella alone	3	8
Patella + fem/tib	16	46
Femur/tib	20	7
None	10	28.5

Electromyographic activity of the VMO and VL was investigated in two subjects while they performed a maximal quadriceps contraction in standing. Both subjects demonstrated an increase in VMO activity during a medial patellar glide whereas VL activity did not change. A medial glide of the patella may therefore increase the efficiency of the VMO in these patients. Further work needs to be done in this area to fully investigate the implications of these findings.

Sixteen patients had positive joint signs on patellofemoral and tibiofemoral passive movements, three had positive signs on patellar movements alone and seven on only tibiofemoral movements. Interestingly, if the patella was held medially while the tibiofemoral movements were being tested the previously positive joint signs disappeared. Ten subjects had no positive passive joint signs.

Treatment Programme

Although a protocol for treating patellofemoral pain was established, the specific treatment for each patient was designed according to the findings from the examination. If a patient had any tight structures he/she was taught to stretch the tight structure first. This applied particularly to the iliotibial band which frequently seemed to be a problem. However iliotibial band stretches seemed to affect the proximal end of the muscle, having no effect on the distal attachment. A strong medial glide and/or medial tilt with the patient in sidelying proved to be much more effective at stretching the tight lateral structures around the knee. This manoeuvre facilitated VMO training, as patellar movement was no longer restricted.

For training to be effective, the patient must not experience pain whilst training as pain has a strong inhibitory effect on muscle function (Spencer *et al* 1984, Stokes and Young 1984). Thus, to enhance VMO activity, the patella must be *firmly* taped to permit a more normal tracking (Figure 2). However, before the patella can be taped, an assessment of its orientation must be made, so that the tape can be appropriately applied. There are three components of patellar orientation which must be examined.

1. *Glide component*

Almost all patients will require a medial glide of their patella. The amount of glide will vary depending on the tightness of lateral structures and the relative amount of activity in the VMO compared with the VL.

2. *Tilt Component*

This is particularly significant if the deep lateral retinacular fibres are tight. The amount of tilt is detected by the therapist using his/her thumb and index finger on the lateral and medial borders of the patella. Both digits should be level. If the medial border sits higher than the lateral border which is commonly the case, the lateral structures are tight and must be stretched. Correction of the lateral tilt can be made by firm taping from the midline of the patella medially. This lifts the lateral border and provides a passive stretch to the lateral structures.

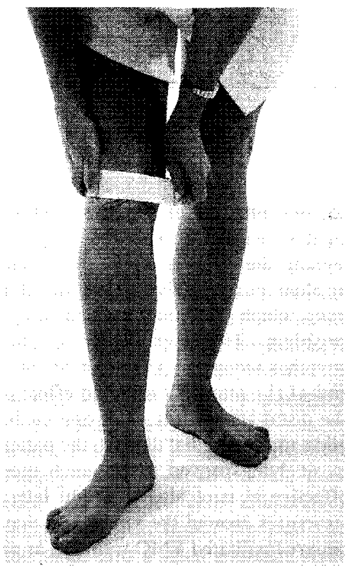

Figure 2: Application of tape.

3. *Rotation component*

The longitudinal axis of the patella *ie* the superior and inferior poles should be in line with the longitudinal axis of the femur. Any alteration in this alignment will affect the pressure distribution to the underlying articular cartilage (Ahmed *et al* 1983). To correct abnormal patellar rotation, firm taping from either the middle inferior pole upwards and medially (to correct external rotation of the inferior pole), or the middle superior pole downwards and medially (to correct internal rotation of the inferior pole) is applied.

A patient may have one or more of these components, and the severity of each of these components will vary from patient to patient. Each abnormal component must be corrected adequately if the patient is going to train and resume all activities in a painfree manner.

As most lower limb activities occur in weight bearing, training the VMO must also be done in weight bearing if a change of symptoms is to occur. However, many patients become symtomatic when sitting for prolonged periods, so specific training can be done during the day whenever the patient is sitting. The instruction to the patient is to tighten the medial quadriceps by using the adductors isometrically without activating the VL. It is important to emphasize to the patient that this is a skilled activity which improves with practice.

Training in a weight-bearing position involves the patient standing in a walkstance position with the symptomatic leg forward and the knee flexed to 30°

Figure 3: Training in a weight-bearing position: walk-stance with the symptomatic knee forward and in 30° flexion.

(Figure 3). The patient is instructed to contract the VMO and to relax the lateral hamstrings and the VL as much as possible. This position is held for a period of ten seconds while the patient supinates the foot just past the midposition and then allows the foot to go back into pronation but remaining in a more supinated position than is present in the resting foot position. This is repeated a number of times. The knee is then straightened and the exercise commenced again.

The exercise is repeated with the knee flexed to about 75°. The aim is to train the invertors of the foot so that there is a decrease in pronation in standing and an increase in the awareness of foot posture.

If the patient has difficulty achieving a VMO contraction then it can sometimes be facilitated with the knees in a 'turned out' squat position (a plié). The patient does a quarter-bend knee bend, contracts the VMO of both legs while at the same time relaxing his/her lateral

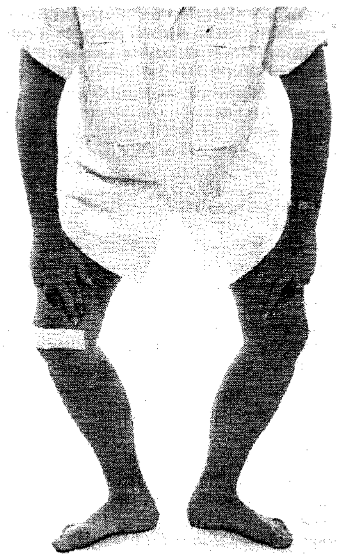

Figure 4: Plié position to facilitate contraction of the vastus medialis oblique.

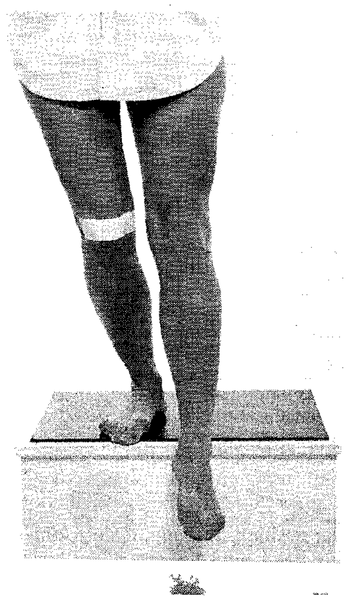

Figure 5: Stepping down from a step for eccentric quadriceps action.

hamstrings and VL as much as possible. He/she then commences the supination and pronation movements of the foot, repeating them a few times before straightening up and starting the routine again (Figure 4). This process can be repeated in a half squat and when the patient's pain has decreased significantly, or when greater outer range quadriceps control is required, the three-quarter squat position is added.

It must be emphasized that the exercises should only cause a minimal amount of discomfort, and that the patient should adjust the tape if an increased amount of pain is experienced. This applies particularly to patients with extremely tight lateral structures as the tape loses its effectiveness fairly quickly.

Training a muscle eccentrically causes a muscle to hypertrophy (Goldberg 1967, Gutman 1971). As much of the quadriceps action in the upright position is eccentric, and hypertrophy as well as control of the quadriceps is desired, then eccentric training must be included in the patient's regime of quadriceps exercises. Most patients with patellofemoral pain complain of pain when walking down stairs so this action must be practised. The patient is instructed to step down from a step and then back up while the quadriceps of the leg remaining on the step contracts eccentrically then concentrically (Figure 5). This is performed at the patient's own speed to begin with, then the patient is requested to go as slowly as possible and later, to go as fast as possible, without sacrificing accuracy of the movement. Emphasis should be placed on alignment and symmetry of the lower limb during this activity.

These exercises may be progressed by altering the height of the step and/or by providing resistance to the movement either during treatment by adding a weight around the ankle or at home by either using the weight or wearing a backpack with a known amount of weight inside. The weight of course can be increased.

As the patient improves it is important to examine the requirements of the quadriceps and other lower limb musculature during his/her sporting activity, so that training specific to that sport can be commenced. For example, a cyclist with knee pain who is hill climbing has different requirements to those of a netballer leaping to catch the ball or a marathon runner running down hills.

Paramount to the success of this programme, is a thorough understanding by the patient of the underlying mechanism causing the problem and the role exercise plays in realigning the patella and thus decreasing the pain. The patient must, therefore, regularly practise the exercises at home and the therapist must check the exercises each time the patient comes so any problems can be resolved and the effectiveness of the exercises can be evaluated.

Results of the Treatment

The results thus far have been extremely encouraging. After two treatment sessions twelve patients had no pain on both subjective and objective evaluation. Fifteen patients had no pain within three to five treatment sessions. Two had no pain after seven treatments. Three patients reported significant decreases in pain after three treatments but these patients are still receiving treatment. One patient felt that after three treatments she had not improved, even though objectively she had improved. She is no longer coming for treatment. Two patients did not attend after the initial examination because they left the State — one is teaching in Queensland, the other has gone overseas. Overall, over ninety per cent of patients responded quickly and favourably to the treatment (Table 8).

Interestingly, all the positive passive tibiofemoral joint findings disappeared after altering the joint mechanics.

To date, only fourteen patients (40%) have not had any treatment for at least six months. All of these patients are still painfree and participating in sporting activities with no prob-

Table 8:
Results of Treatment

	Number of Treatments	Number of Patients	%
No Pain	<3	12	34
	3-5	15	43
	5-7	1	3
	8	1	3
	Total	29	83%
Decreased pain		3	8.5
	Total	32	92%
No Change		1	3
Unknown		2	5

lems. They are all doing their exercises, two had stopped their exercises temporarily and found that they had a slight return of symptoms. The symptoms disappeared once they resumed their exercise programme.

Conclusion

There are two factors which are essential in the management of patellofemoral pain. First, a thorough analysis of the problem must be made to identify the contributory factors. Each factor must be specifically addressed to affect a change in patellofemoral alignment. Second is the context specific training of the muscles contributing to patellar alignment. Of prime importance is the quadriceps muscle which after specific training may be 'set' so it is activated in advance to prevent lateral tracking of the patella. Specific training of the invertors and supinators of the foot to increase awareness of foot position may also assist in altering lower limb position and hence patellar tracking.

The training must however, be relatively painfree in order to enhance muscle control. The quadriceps muscle is inhibited by pain and/or effusion in the knee joint so that if exercises are painful there may be a detrimental rather than a beneficial effect on patellar position. Initially, maltracking of the patella may be altered by appropriate taping. Later, it seems that the quadriceps muscle resumes this responsibility, so use of external supports such as the Palumbo brace is not necessary. Further investigation is required to substantiate this claim. It does appear, however, that patients with patellofemoral pain have an imbalance between the activity in the VMO and VL components of the quadriceps. Taping of the patella to enhance contraction of the VMO is critical in the initial stages of treatment.

Clinical evidence to date suggests that context specific training of the muscles contributing to patellar alignment, particularly the quadriceps muscle, is possible. As long as training is maintained, the effects seem to be long term and the patient can remain asymptomatic even when participating in activities which are demanding for the patellofemoral joint.

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